Record carrier, playback apparatus and information system comprising a record carrier and a playback apparatus.

In USP 5 930 210 a record carrier, a playback apparatus and information system comprising a record carrier and a playback apparatus is described. The record carrier described therein comprises first variations caused by existence and nonexistence of information marks along the track. Said first variations represent an information signal recorded on said record carrier. The information marks are for example in the form of pits. The record carrier further comprises second variations caused by variations associated with the information marks. The document referred to above describes an embodiment, wherein the second variations are in the form of variations in the radial position. The information marks are arranged along a wobbled track, the wobble having a frequency which is beyond the nominal range of a tracking servo system. This allows the second variations to be detected from the radial error signal. The second variations represent a decryption key which is necessary for decoding the content of the information in the information marks. Due to the fact that a bit copying machine usually only copies the variations of the first physical parameter (which variations represent the information recorded) the variations in the second physical parameter are not copied. Consequently the special discs cannot be copied by the usual type of bit copying machines.

Such a combination of first and second variations is also proposed for a record carrier according to the CD2 standard. It is necessary that such a record carrier can be reproduced on a player which employs 3-beam radial tracking as well as one which uses the radial push-pull method. However in a player comprising a three beam radial tracking system, the two satellite detectors have a relatively large tangential distance. As the radial wobble has a relatively high frequency, e.g. 22.05 kHz in the case of a 1X playback speed, this results in a relatively large phase shift between the signals of the two satellite detectors, which hinders a reliable detection of the wobble signal. Alternatively if the wobble signal is derived from only one of the signals of the sattelite detector, it has a relatively large signal to noise ratio, which also hinders a reliable detection of the wobble signal.

It is a purpose of the present invention to provide a record carrier which enables a playback apparatus to more reliably detect the second variations. It is a further purpose of the invention to provide a playback apparatus which more reliably detects the second variations. It is a further purpose of the invention to provide an information system comprising a record carrier and a playback apparatus in which the second variations are reliably detected.

According to the invention the record carrier has information marks along a track thereof and exhibits first variations caused by existence and nonexistence of the information marks along the track, said first variations representing an information signal recorded on said record carrier, and second variations caused by variations associated with the information marks; the phase of the second variations being coupled to the phase of the first variations.

The record carrier according to the invention is in particularly suitable for playback on a playback apparatus according to the invention including:

a transducer unit for scanning said record carrier, said transducer unit being adapted to detect said first variations and said second variations,

a first recovery unit coupled to the transducer unit for recovering a clock signal from the first variations,

a second recovery unit coupled to the transducer unit for recovering an information signal from the first variations,

a detection unit for detecting whether said second variations exhibit a predetermined variation pattern on the basis of at least one signal, which is at least indicative of said second variations, originating from said transducer unit, the detection unit using the said clock signal for detecting and

an enabling unit for enabling said second recovery unit to recover the information signal when said detection unit detects said predetermined variation pattern.

As the phase of the second variations is coupled to the phase of the first variations, the clock signal obtained by the first recovery unit can be reliably used by the detection unit for detecting the second variations. Using a more reliable clock signal also results in a more reliable detection by the detection unit.

It is noted that EP 485 234 describes an information recording device for recording information at a record carrier which comprises tracks which are radially wobbled. The radial wobble represents an address. During recording of data, a recording clock is recovered from the radial wobble. In this information system the information stored in the

wobble has no further meaning after the information has been retrieved from the record carrier.

It is further noted that DE 199 00 653 discloses a device for making a master disc in which a wobbled track as well as pre-pits are applied. In order to prevent the occurence of overlapping pre-pits the control signals for applying the wobble and for applying the pre-pits are mutually synchronized to each other. In this case the wobble contains information to control the rotation speed of the record carrier.

It is further noted that USP 5 930 210 shows an embodiment in Figure 5, wherein the detection unit receives the clock signal which is recovered by the PLL from the first variations. In this case the clock signal itself serves as the signal representing the second variations. No independent clock signal is used which could improve the reliability of detecting the signal representing the second variations if the latter is unreliable by noise.

An embodiment of the information system is characterized in that the second variations exhibit a modulation pattern representing a code, that the detection means comprises code recovery means for recovering the said code from the detection signal and means for activating the enabling means in response to the recovery of said code.

The use of a modulation of the variations has the advantage that the presence of the variations of the second physical parameter can be detected more reliably.

A further embodiment of the information system is characterized in that the information recorded is of a type which is recoverable by means of a predetermined data processing, the code represented by the modulation pattern of the second variations indicating the type of data processing to be used for recovering the information, the apparatus being provided with means for setting the recovery means in a mode in which the predetermined data processing indicated by the code recovered is performed.

This embodiment has the advantage that for recovering the information read from the record carrier it is required that the code represented by the modulation pattern is available. So the information can only be recorded by a dedicated play back apparatus, which is able to recover the code. In the event that the information is encrypted or scrambled before it is recorded on the record carrier the code preferably indicate the encryption key or the scramble method respectively.

Although not limited to an information system in which optically readable record carriers are used, the system is in particular suitable for this type of information systems.

In an optical record carrier it is relatively simple to provide the track in which the information has been recorded with a track modulation which can be detected by the same radiation beam as used for reading the information.

An embodiment of the information system in which this is realized, is characterized by servo control means for controlling the scanning in order to control at least one scanning parameter to a predetermined value on the basis of a detection signal received from the radiation sensitive detector and which is affected by said second physical parameter, which servo control means having a predetermined frequency bandwidth, said variations of said second physical parameter causes variations in the detection signal which exhibit a frequency spectrum which is located outside the bandwidth of servo control means and outside the frequency spectrum of the signal variations caused by the variations of the first physical parameter.

The variations in the second physical parameter can be in the form of variations in the track position in a direction transverse to the track direction. These variations can be detected on the basis of the tracking error signal.

The variations in the second physical parameter can be in the form of variations in the position of the plane in which the optically readable marks are located. In that event the variations can be detected on the basis of the focus error signal.

The variations in the second physical parameter can also be in the form of a variations in the mean value of the optical readable marks and the intermediate areas located between the optically readable marks. In that event the variations in the second physical parameter can be detected on the basis of variations in the data clock signal recovered during the scanning of the track with a constant linear velocity.

In the event that the record carrier used in the information system is a Compact Disc it is preferred to use an information system which is characterized in that the variations in the second physical parameter result in variations in the detection signal with a frequency substantially corresponding to 22 kHz in the event that the track is scanned with a scanning speed between 1.2 to 1.4 meter per second.

This embodiment has the advantage that it is impossible to copy the special disc on an usual recordable Compact Disc which is provided with a pregroove which exhibits a wobble which results in a tracking error with a frequency of substantial 22 kHz when the pregroove is scanned with a velocity between 1.2 and 1.4 meter per second. Even in the event that it succeeds to record a wobbling pattern of recording marks which corresponds to the wobbling recording marks of the record carrier to be copied, this pattern will not be detectable because

of the presence of the wobbling pregroove which is situated in the same frequency range.

These and other aspects of the invention are described in more detail with reference to the drawing.

Therein Figures 1a, 1b, 1c, 1d and 2 show possible embodiments of a record carrier 1 for use in the information system in accordance with the invention,

Figure 3 schematically shows an information system according to the invention comprising a record carrier as well as a playback device 20 according to the invention,

Figure 4 schematically the representation of a code by the second variations,

Figure 5 shows a first unit of the playback apparatus of Figure 3 in more detail,

Figure 6 shows a second unit of the playback apparatus of Figure 3 in more detail,

Figures 7A to 7F show a plurality of signals occuring in the playback apparatus shown in Figure 3.

Figures 1a, 1b, 1c, 1d show possible embodiments of a record carrier 1 for use in the information system in accordance with the invention, Figure 1a being a plan view, Figures 1b and 1c being highly enlarged plan views of a part 2 of a first and second embodiment of the record carrier 1, and Figure 1d showing a small part of a sectional view of the part 2 along a line b--b of a third embodiment of the record carrier 1.

In the embodiment of the record carrier 1 shown in Figure 1b the variations in first physical parameters have the form of optical detectable marks 3 which alternate with intermediate areas 4. The optically detectable marks may be in the form of so-called pits. However also other type of optically detectable marks are suitable. The optically detectable marks are arranged along a track of which the center line is indicated by a reference sign 5. In this embodiment the variations in the second physical parameter are variations of the track position in a direction transverse to the track direction. This position variation has the form of a track undulation, also known as a radial track wobble. Such track wobble can easily be detected by the same beam scanning unit as used for the detection of the optically detectable marks 3 as will be discussed in an other part of the description. The phase of the second

variations is coupled to those of the first variations in that a predetermined number of wobbles corresponds to a predetermined number of channel bits represented by the first variations.

In the embodiment shown in Figure 1c the variations of the second physical parameter have the form of variations of the width of the optical detectable marks 3. The variations in the width of marks 3 result in a additional intensity modulation in a radiation beam scanning the track. Both the variations in the width of the marks 3 and the information can be recovered on the basis of the intensity modulation, provided that the frequency spectrum of the component caused by the pattern of marks does not overlap the frequency spectrum of the component caused by the mark width variations. The phase of the second variations is coupled to those of the first variations in that a predetermined number of width variations corresponds to a predetermined number of channel bits represented by the first variations.

In Figure 1d the reference sign 6 indicates a transparent substrate. The substrate 6 is covered with a reflective layer 7. The reflective layer 7 is covered by a protective layer 8. The substrate 6 is provided with optically detectable marks 3 in the form of pits. The variations in the second physical parameter are in the form of the variations of the position of the plane in which optically detectable marks 3 are situated. In Figure 1d different positions of these planes are indicated by lines 9_A and 9_B. When scanning the pattern as shown in Figure 1d with a focused radiation beam the variations in the plane of the marks 3 result in a focus error which can be detected easily. The phase of the second variations is coupled to those of the first variations in that a predetermined number of variations of the position of the plane corresponds to a predetermined number of channel bits represented by the first variations.

Figure 3 schematically shows a record carrier 1 according to the invention described with reference to Figure 1A, as well as a playback device 20 according to the invention. The track 11 shown exhibits first variations caused by existence and nonexistence of information marks along the track. The first variations represent an information signal recorded on said record carrier. The information signal is in casu a runlength limited sequence of bits. In particular the information signal is encoded according to the EFM-code. The track also exhibits second variations caused by variations associated with the information marks. In the embodiment shown the second variations are in the form of a radial wobble of the track as was described with reference to Figure 1A. The phase of the second variations is coupled to those of the first variations. In the embodiment shown the phase of the second

variations is coupled to those of the first variations in that each EFM-frame corresponds to three periods of the wobble in the track, and starts at a zero-crossing of the radial wobble.

In the embodiment shown the second variations have either a first or a second phase with respect to the first variations. As is illustrated in Figure 4, the radial wobble W represents a binary code. The binary code, e.g. 1110 is biphase modulated. For example each '1' is converted in a '10' and each '0' in a '01'. The binary code 1110 is converted into the binary sequence 10101001 in that case. The so obtained binary sequence is converted in a radial wobble W in that the radial position of the marks is variated with a fixed frequency, but with either a first or a second phase, with respect to the first variations. At each polarity change of the binary sequence obtained by conversion the phase of the second variations is toggled between the first and the second phase. The first and the second phase differ with 180 degrees. This has the advantage that the signal S_A representing the second variations can be sampled with a frequency twice the frequency of the second variations, such that each sample is a maximum regardless whether the phase equals the first or the second phase.

In the present embodiment the first and the second phase are selected such that a zero crossing of the second variations coincides with the start of an EFM-frame. This has the advantage that the EFM-frame sync can be used easily also for resynchronizing the clock which is used for detecting the second variations. However any predefioned phase relationship between the first and the second variations could be used, provided that it is either standardized, or that the phase relationship is recorded at the record carrier.

The playback device 20 shown in Figure 3 comprises a transducer unit for scanning the record carrier 1, with tracks 10, 11, 12. The transducer unit is adapted to detect the first variations and the second variations. In the embodiment shown the transducer unit comprises an optical unit and a first, a second, and a third detector 20_A, 20_B, 20_C. The optical unit projects a central spot B and two satellite spots A, C at the record carrier. As the three beam method as such is well known, the optical unit is not shown. The radiation reflected from said spots A, B, C is detected by the first 20_A, the second 20_B, and the third detector 20_C. The playback apparatus further comprises a first 22 and a second recovery unit 23 coupled to the transducer unit. The first 22 and the second recovery unit 23 respectively recover a clock signal CL and an information signal S_{out} from the first variations. The playback apparatus 20 further comprises a detection unit 24 for detecting whether said second variations exhibit a predetermined variation pattern on the basis of at least one signal S_A, which is at least indicative of said second variations, and which originates from said transducer unit.

The playback apparatus further comprise an enabling unit 25 for enabling the second recovery unit 24 to recover the information signal S_{out} when said detection unit 24 detects said predetermined variation pattern.

The detection unit 24 uses the said clock signal CL generated by the first recovering unit 22 for detecting.

Figure 5 shows an example of the first recovery unit 22 in more detail. The first recovery unit 22 comprise a phase detector 22.1 for detecting a phase difference between the signal SB received from the second detector 20B and the clock signal CL generated by the first recovery unit 22. An output signal of the phase detector 22.1 is passed via a loopfilter 22.2 to a controllable oscillator 22.3, e.g. a voltage controlled oscillator. An output of the controllable oscillator constitutes the clocksignal CL generated by the first recovery unit.

Figure 6 shows the detection unit 24 in more detail. The detection unit 24 comprise a first frequency divider 24.1 for generating a first auxiliary clock signal CL1 out of the clock signal CL. The first auxiliary clocksignal CL1 has a frequency which is a factor N lower than the frequency of the clock signal CL. In the present case, where the duration of an EFM-frame corresponds to three wobble cycles the value of N equals 98. In the embodiment shown the frequency divider 24.1 has a further input for receiving the signal SYNC, which indicates the start of each EFM-frame. The output signal CLW of the frequency divider 24.1 has a phase which is coupled to the phase of the clock signal CL derived from the first variations. A sample and hold unit 24.2 samples the signal S_A at each positive transition of the clock signal CLW and generates the signal S_{ACL} in response. The signal S_{ACL} is provided to a threshold unit 24.3, which generates a binary signal S_2.

Figure 2 shows an example of a detection unit that can be used in the event that a modulated radial wobble is used. This detection unit comprises a band pass filter 80 tuned to the frequency of the radial wobble. The input of the filter 80 is coupled to the detector 20_A so as to receive the signal S_A. The output of the filter 80 is supplied to a demodulation circuit 81 for recovering the code represented by the modulated wobble, by using the clock signal CLW which is obtained by dividing the EFM clock signal CL with frequency divider 83. The code recovered by the demodulation circuit 81 is supplied to a comparator circuit 82 for comparing the code recovered with a predetermined code. The comparator circuit 82 is of a type that generates an enabling signal for the recovery circui in the event that the code recovered by the demodulation circuit 81 corresponds with the predetermined code.

The operation of the apparatus according to the invention is now furthe

described with reference to Figure 7. Figure 7A schematically shows the signal S_B, which comprises the EFM coded information. The signal S_B comprises a sequence of frames F comprising a sync pattern F_1 of 24 channel bits and a data-portion F_2 of 564 channel bits. The clock signal CL (also schematically shown in Fig 7B) deduced therefrom has a frequency of 4.3218 MHz. The clock signal CLW (Figure 7C), generated by the frequency divider 24.1 has a frequency of 44.1 kHz. This clock signal CLW is coupled in phase to the signal S_A, as the second variations, in this case the radial wobble W (Figure 7D) of the information marks is coupled in phase to the phase of the first variations, i.e. the information marks. In this case a positive transition of the clock signal CLW coincides with a maximum deviation of the wobble W. Figure 7D also shows the signal S_A which is representative of the second variations W. As shown therein the signal SA has a relatively large noise component. However, as the signal SA can be reliably sampled at those points in time where the wobble W has a maximum deviation, the polarity of the wobble W at those points can be reliably determined as illustrated in Figures 7E and 7F. Figure 7E shows the signal S_{ACL} provided by the sample and hold unit 24.2 and Figure 7F shows the signal S_2 provided by the threshold unit 24.3.

It is noted that the signal processing operations of the player could be executed by dedicated hardware as well as by a general purpose processor which is suitably programmed.

It is remarked that the scope of protection of the invention is not restricted to the embodiments described herein. Neither is the scope of protection of the invention restricted by the reference numerals in the claims. The word 'comprising' does not exclude other parts than those mentioned in a claim. The word 'a(n)' preceding an element does not exclude a plurality of those elements. Means forming part of the invention may both be implemented in the form of dedicated hardware or in the form of a programmed general purpose processor. The invention resides in each new feature or combination of features